Gemini Multi-Obect eXtra-wide-band Spectrograph (GMOX)

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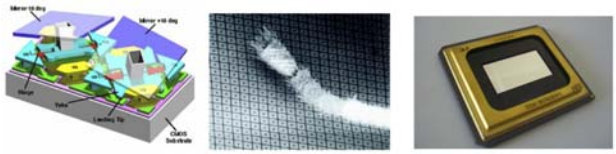
Abstract:

We propose to build GMOX, the Gemini Multi-Object eXtra-wide-band spectrograph. We envision GMOX as a wide-band spectrograph covering the entire optical/near-IR spectrum accessible from the ground (from the U-band at 3200 Å, up to the K-band at 2.4 um) with resolving power $R \approx 5{,}000$, adequate to mitigate the effect of telluric airglow lines. Using existing MEMS technology, GMOX can simultaneously acquire hundreds of spectra of faint sources in crowded fields, with unparalleled spatial resolution. To reach the ultimate sensitivity, GMOX can exploit the exceptional image quality of the Gemini Multi-Conjugate Adaptive Optics System (GeMS) on Gemini South or Altair on Gemini North. Thanks to its versatility, we expect GMOX to become a workhorse instrument for major surveys, highly requested and extremely productive. GMOX finds natural application in almost every field of astrophysics, in particular in studies of crowded fields like globular clusters, the Galactic Bulge, the Magellanic Clouds, nearby galaxies, clusters of galaxies and the high-z frontier. Future facilities like JWST, LSST and WFIRST will dramatically increase the demand for spectroscopic followup; GMOX will allow Gemini to play a major role well into the next decade.

GMOX is comprised of three arms (Blue, Red and Near-IR) observing a ~ 83" x 44" field with the f/33.2 beam from GeMS and ~ 170" x 90" with the native f/16 beam from the Gemini telescopes, and with Altair. Through two dichroic beamsplitters, the focal plane is reimaged onto three Digital Micromirror Devices (DMDs) of the latest generation, commercially available; each DMD samples the field with 2048 x 1080, 14 um square micromirrors, sampling 0.040"/mirror at f/33.2 and 0.083"/mirror at f/16. Each mirror can be randomly addressed and tilted by ±12°; those tilted in the ``ON'' state reflect the light to the spectroscopic channel, acting as slits. The multitude of other mirrors left in the ``OFF'' state reflect the field into an ancillary imager for target acquisition and AO tip-tilt control. The Near-IR arm is split into three channels, dedicated to the Y+J, H and K-bands. With a total of two large format CCDs and three H4RG IR detectors, the full spectra of all targets are simultaneously collected.

We estimate that under normal seeing conditions GMOX approaches signal-to-noise = 6 at m(AB)≈22 in 1000s, per resolution element. In the best seeing conditions, the capability of using ultra-narrow slits with minimal sky background allows GMOX to reach extreme sensitivity across the entire spectrum.

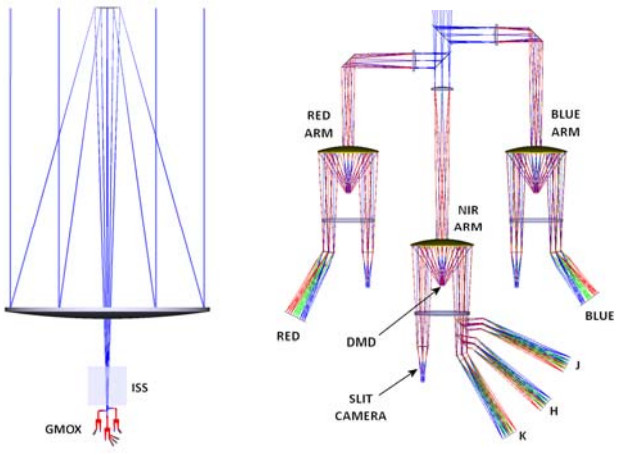
The possibility of defining slit widths by multiples of 0.083" is, in fact, critical. GMOX can instantaneously and optimally align slits that with any other approach would be completely impractical to handle, especially given the intrinsic variability of an AO-fed system. GMOX removes the need for pre-imaging weeks in advance and fully relaxes the requirements on long-term stability of the focal plane. It also allows real-time monitoring of the perfect slit alignment during the longest integrations, and extends AO-controlled science into the visible range.



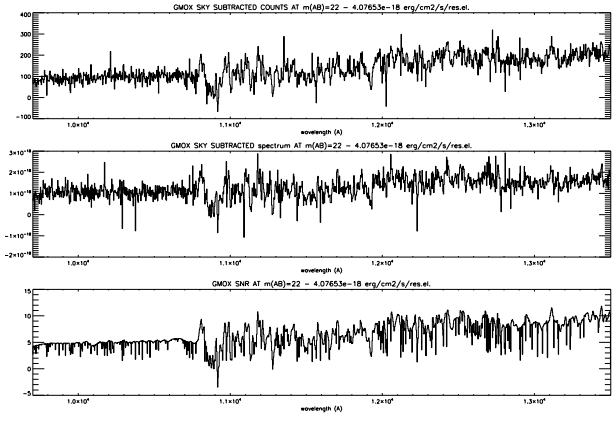
Left) typical substructure of a TI DMD; Center) an early DMD array with an ant leg for comparison; and Right) packaged DMD CINEMA (2048 x 1080) device.

Channel	WL (nm)	R	Slit width arcsec	Slit width mirrors	Grating angle	Grating l/mm	Spectral length mm	Spectral length pixels	Beam Ø (mm)	Camera f/#	Camera FL (mm)	Camera FOV (deg)
Blue	320.0 458.5 589.0	2792 4000 5139	0.417	5	18.0	1348	71.7	7173	101	1.834	184.7	21.0
Red	589.0 797.2 1000.0	3317 4500 5632	0.333	4	16.3	702.5	70.2	7024	101	2.293	230.8	17.3
Y+J	970.0 1160.6 1350.0	2793 3342 3887	0.250	3	10.3	309.0	45.2	3015	90	4.203	378.2	10.3
H	1460.0 1636.8 1810.0	4565 5118 5660	0.250	3	15.6	328.6	45.2	3015	90	4.203	378.1	10.3
K	1930.0 2191.9 2450.0	4062 4613 5156	0.250	3	14.1	222.8	45.2	3015	90	4.203	377.9	10.3

First-order optical parameters defining the 5 proposed spectroscopic channels of GMOX. Slit widths on the sky are for the f/16 native beam from Gemini and would be reduced by roughly a factor of 2 for the f/33.2 beam from GeMS.



Optical layouts of a preliminary concept for GMOX. (a) GMOX on Gemini, shown beneath an ISS-sized cube for scale. (b) Schematic of a 3-arm arrangement for GMOX.



Spectral output from the GMOX exposure time calculator for a galaxy (template from Brown et al. 2014) , m(AB)=22, with GeMS using a 3 x 3 micromirror slit (0.125 x 0.125 arcseconds) in the Y+J band.